I. C. 6921 DECEMBER 1936

DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

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MINING AND GRINDING METHODS AND COSTS AT THE DENNISON SEWER PIPE COMPANY CLAY MINE, DENNISON, OHIO

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BY

E. J. LINTNER

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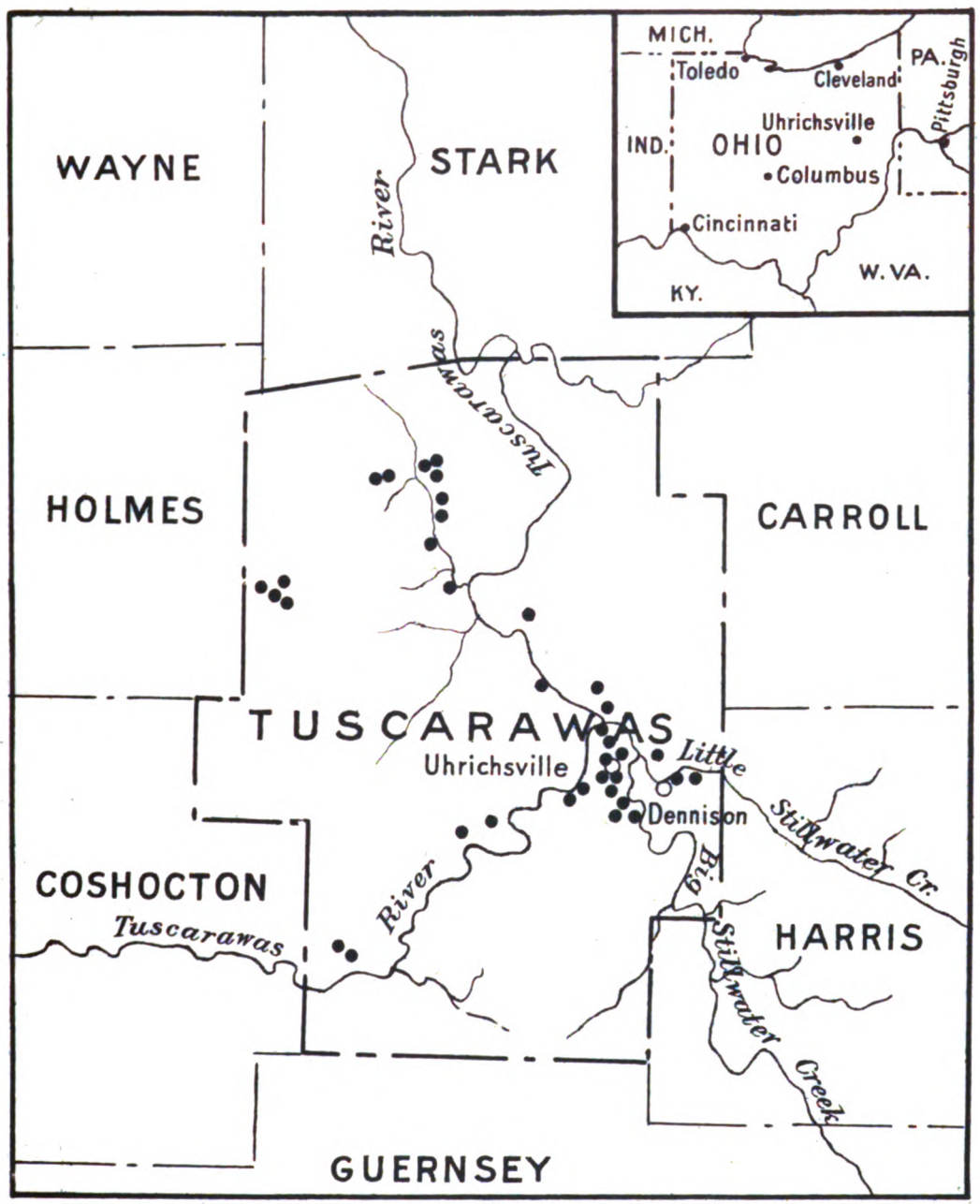

LOCATION OF CERAMIC PLANTS-TUSCARAWAS COUNTY

FIGURE 1.

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MINING AND GRINDING METHODS AND COSTS AT THE DENNISON SEWER PIPE CO. CLAY MINE, DENNISON, OHIO 1/

By E. J. Lintner 2/

INTRODUCTION

This paper is one of a series being prepared by the United States Bureau of Mines describing clay mining, crushing and grinding methods, and costs at various clay-mining operations throughout the United States. These papers are designed to disseminate technical information regarding methods used. The cost tabulations represent local operating expenditures only and not total production costs. Although the publication of total production costs might not be advisable in some instances, yet a knowledge of operating costs is essential to the technical discussion and study of the methods employed. The attention of the reader is specifically called to this distinction between total and operating costs in order that no misunderstanding of the cost tabulations shall ensue.

The following report deals specifically with the methods employed by the Dennison Sewer Pipe Co., Dennison, Tuscarawas County, Ohio.

The author wishes to thank the following persons who kindly assisted in assembling these data: S. G. McClave, secretary and general manager, Fred Frey, mine foreman, and Delbert Gowins, plant foreman.

HISTORICAL

Although the clay resources of the area under consideration had been exploited previously, it was not until 1887 that the real growth of the ceramic industry began with the formation of the Diamond Fire Clay Co. Soon thereafter other companies were formed, and the industry grew rapidly. Within a comparatively short time Tuscarawas County exceeded all other counties of the State in production of ceramic wares. By 1928, 41 plants were being operated.

Uhrichsville, Ohio, is the center of the industry, plants being scattered throughout the valley of the Tuscarawas River and its two tributaries - the Little and the Big Stillwater Creeks (fig. 1).

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2/ Associate mining engineer, U. S. Bureau of Mines, Washington, D. C.

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The Dennison Sewer Pipe Co. was organized in 1910 for the manufacture of sewer pipe. A site was selected, and its mineral value was proved by drilling. An adit was driven into the hillside piercing the No. 6 coal bed; a slope was sunk into the bed of fireclay approximately 28 feet below the coal bed; and a large brick building was erected to house the manufacturing operations. The plant is about 1 mile northeast of the town of Dennison on Little Stillwater Creek. It is served by the main line of the Pennsylvania Railroad, while excellent highways also permit rapid trucking service.

GEOLOGY

The clay mined in this district is known as the Lower Kittanning. This is a member of the Allegheny formation, which belongs to the Pennsylvanian system. The Allegheny is the well-known clay-and coal-bearing formation of Ohio. Its thickness ranges from 175 to 250 feet, averaging about 200 feet.[3/] This formation includes all the important clay beds in Ohio; the Lower Kittanning member is by far the most important of the group.

The Lower Kittanning member outcrops across the State, running northeast in a belt 5 to 20 miles wide. It is worked commercially in most of the counties through which it passes. Tuscarawas County, however, ranks as the most important district of the State.

This member is composed of a bed of coal (the No. 5 seam) and the underlying clay bed itself. The clay bed, in turn, is composed of plastic clay underlain by a bed of flint clay. In Tuscarawas County the average thickness of the coal seam is 2 feet 6 inches and that of the plastic clay is 10 feet. The flint clay ranges in thickness from 1 to 10 feet, averaging about 4 feet.[4/]

As the Allegheny is also the chief coal-bearing formation of Ohio, the fuel required in manufacturing is near at hand. The Lower Kittanning or No. 5 coal, which lies directly over the clay member, is of very poor quality; consequently, it is left in place. The Middle Kittanning or No. 6 coal bed, lying about 24 feet above the No. 5 bed, is of excellent quality and is used throughout the district. The surrounding terrain is hilly and is traversed by the Tuscarawas River and its tributaries.

PHYSICAL CHARACTERISTICS

The plastic clay ranges from light to dark gray in color. Its texture is very fine and its bonding power high, although it disintegrates readily upon exposure to the atmosphere.

The flint clay is dull-gray and is rather dense and hard. Upon weathering it slakes readily, producing fragments with sharp edges and corners.[5/]

3/ Stout, W., Stull, R. T., McCaughey, W. J., and Demorest, D. J., Coal-Formation Clays of Ohio: Geological Survey of Ohio Bull. 26, 1923, p. 243.
4/ Stout, W., Stull, R. T., McCaughey, W. J., and Demorest, D. J., Coal-Formation Clays of Ohio: Geological Survey of Ohio Bull. 26, 1923, p. 272.
5/ Work cited in footnote 4, p. 272.

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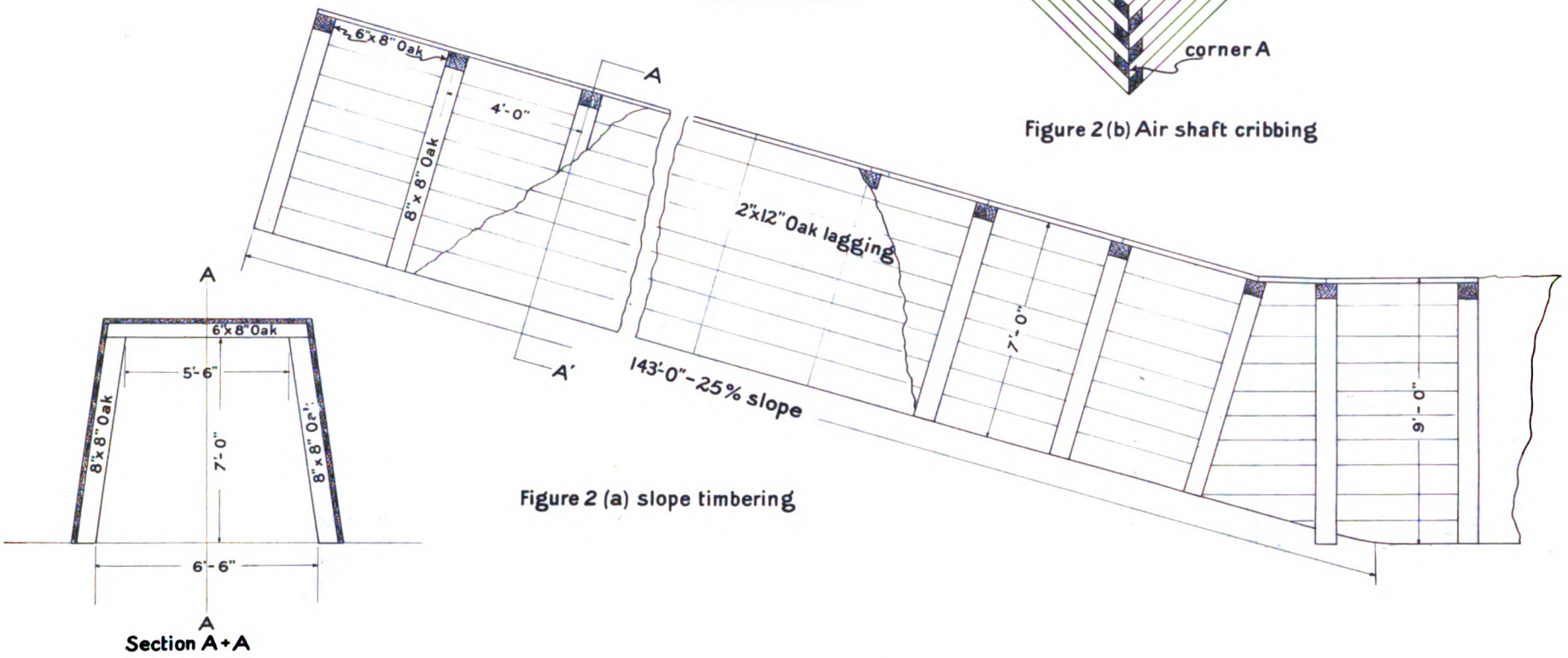
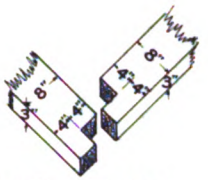


Figure 2 (a) slope timbering



Detail corner A

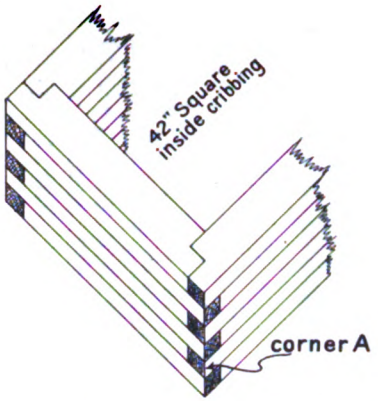


Figure 2 (b) Air shaft cribbing

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Only plastic clay is mined here. Its thickness is about 9 feet throughout the mine. The thickness of the overlying No. 5 coal bed is 4 feet.

METHODS OF PROSPECTING AND EXPLORATION

Before operations were begun test holes were put down with a churn drill at various intervals on the property. Since the Lower Kittanning clay bed is so persistent in areal extent, the problem was not to locate it but to determine its thickness and that of the No. 6 coal seam. Although no records of the test holes are available, a geological section taken near by shows the following structure:6/

	Feet	Inches
Shale	10	0
Coal, Middle Kittanning	3	8
Shale, clay and sandstone	28	0
Coal, Lower Kittanning	3	6
Clay, light, plastic, Lower Kittanning	5	6

METHODS OF SAMPLING AND ESTIMATION OF TONNAGES AND VALUES

At the time the property was drilled an estimate was made of the total amount of clay and coal present. The clay seam being worked is so uniform throughout that it is not necessary to sample and test it continually to maintain the proper quality of the finished products. A chemical analysis of the clay is as follows:

	Percent
Silica, SiO_2	64.78
Alumina, Al_2O_3	23.22
Iron oxide, Fe_2O_3 ..	1.39
Titania, TiO_2	1.93
Lime, CaO	.68
Magnesia, MgO	1.20
Alkalies	.39
Ignition loss	7.28

METHODS OF DEVELOPMENT AND MINING

The Lower Kittanning member is usually found above the water level in the surrounding hills. The practice in this district is to drive a slope from 10 to 25 percent downgrade into the clay bed. After the bed is reached either a single- or a double-entry room-and-pillar system of mining is employed.

The slope entering the mine of the Dennison Sewer Pipe Co. is 14°, or approximately 25 percent, downgrade (fig. 2, a). It is 155 feet long from the entrance to the foot and 5 feet 6 inches wide and 7 feet high inside the timber sets. Three-piece timber sets of square-cut oak timber are placed on 4-foot

6/ Work cited in footnote 4, p. 309.

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centers and lagged with 2-inch by 12-inch oak throughout its length. The posts measure 8 by 8 inches and the cap pieces 6 by 8 inches. Figure 2a illustrates the method of timbering.

Rooms, entries, and crosscuts are driven 12 feet in width and as a rule on approximate 100-foot centers in the present workings.

The coal member above the clay bed is of such poor quality that it is left in place. Above this coal lies a bed of shale. A large amount of timbering is necessary to hold these strata in place. The usual procedure followed in the timbering operation will be discussed later.

Approximately 28 feet above the Lower Kittanning clay bed is the coal mine in the Upper Kittanning or No. 6 seam of coal. That portion of the coal seam over the clay mine has long since been worked out and abandoned. Consequently, a large amount of water from this old mine seeps through the soft intervening strata into the clay mine, making it very wet and muddy. The volume of water encountered during the rainy season is quite large. This point will be discussed further under "Pumping."

The mine will produce approximately 120 tons of clay in an 8-hour shift with a minimum underground crew of 14 men in addition to the foreman. Approximately 25 men are employed in the coal mine, and the average production is 70 tons per day. The section of the seam being worked at present lies east of the plant. The accompanying map (fig. 3) shows the plant layout and the mine workings. The old, abandoned coal mine is not shown.

MINING METHODS

Drilling

A one-man hand-auger drilling machine is used to perform the necessary drilling. It weighs only a few pounds and consists essentially of a solid feed bar 1-1/8 inches in diameter and 48 inches in length, having 6 threads to the inch. This is rotated by means of a handle at one end. The bar is fed through a bronze thread box fitted with lugs that permits its mounting on a small split or double wooden column. The thread box is split so that the feed bar can be inserted or removed very easily and quickly. The drill column is notched, permitting easy adjustment of the drill for the various holes (figs. 4 and 4,a).

Twisted drill steel 1-3/4 inches in diameter is made up in sets of three lengths (2, 4, and 6 feet) for use with fishtail cutting bits. An extension bar 3/4 inch in diameter and 2 feet long is used to drill the holes to completion. A hole 3 inches in diameter and 7 feet deep is usually drilled.

The driller selects the proper location and erects the column approximately 4 feet from the face and directly behind the place where the row of holes is to be drilled for the rib line. With a pick a small hole is made in the clay face where the hole is to be started. The drill steel is inserted in the flat tapered socket in the feed bar, the machine placed on the drill column, the

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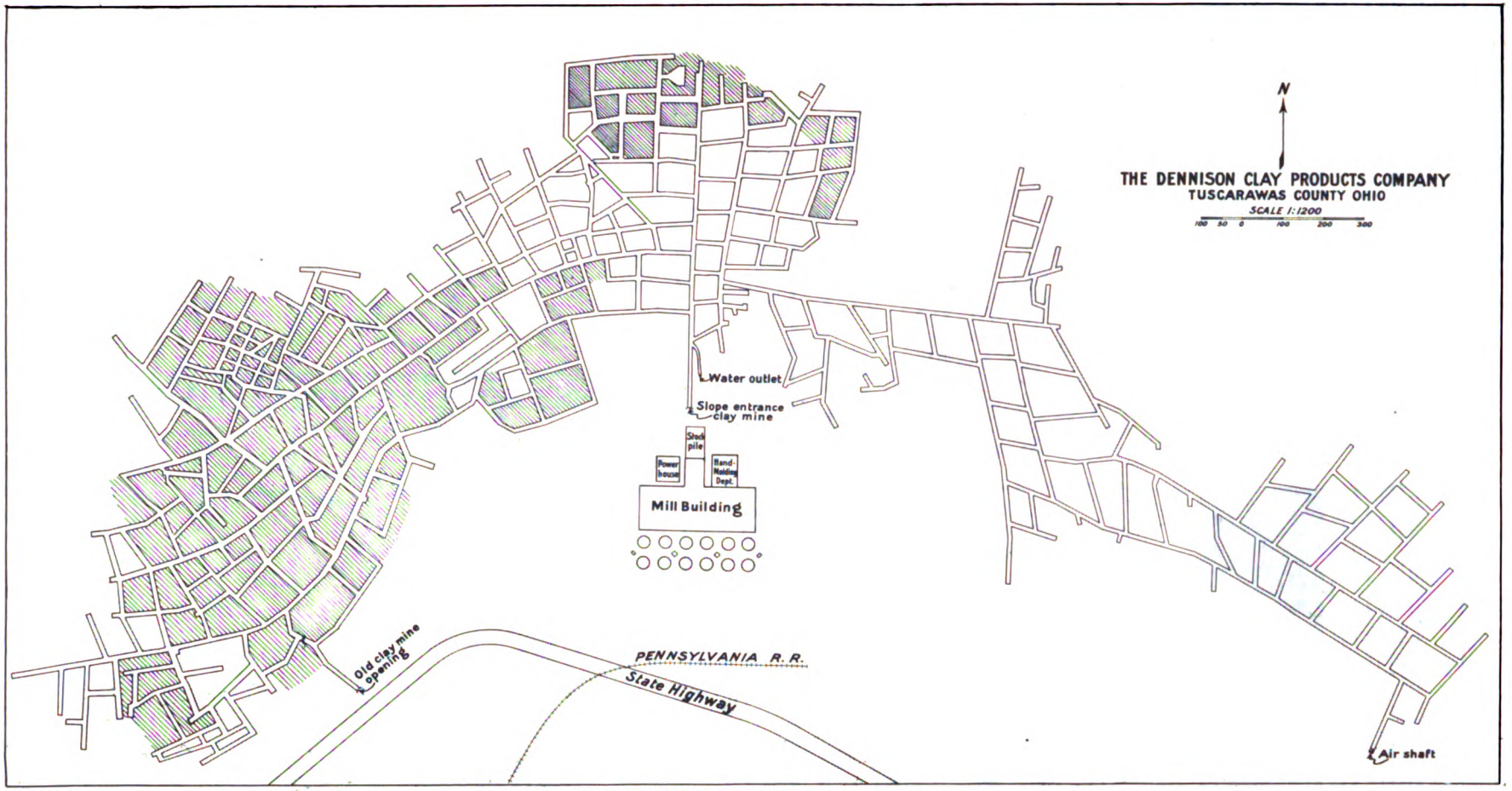

Figure 3.– Mine-plant layout.

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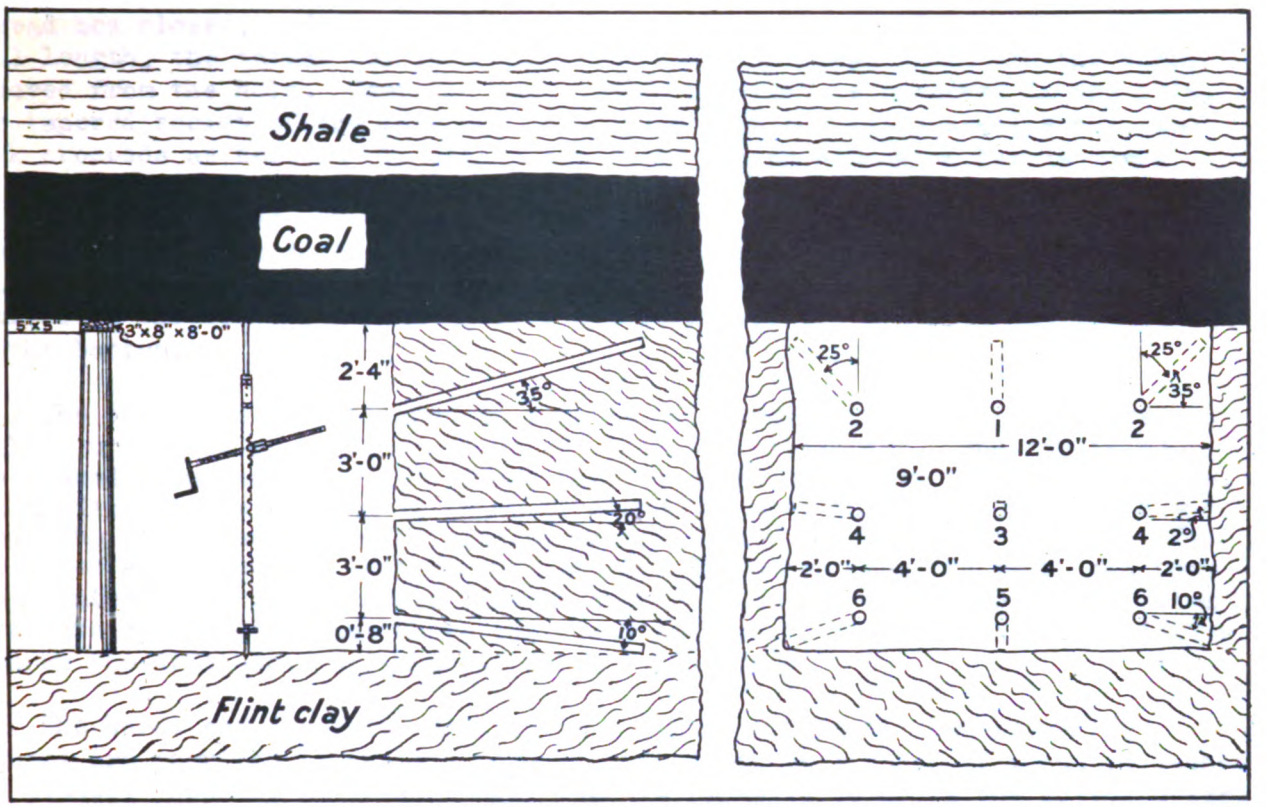

Figure 4.– Drill-hole arrangement.

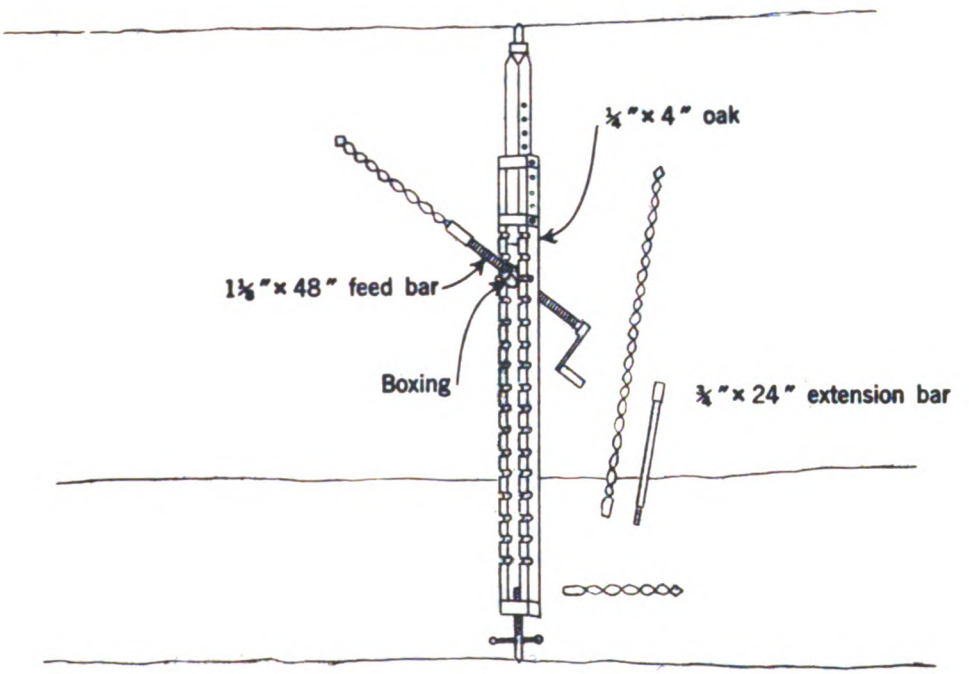

Figure 4a.– Drilling machine.

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thread box closed, and the drilling started. When the steel has advanced its full length, the thread box is opened, the feed bar moved back, and the steel removed from the hole. Then the next length of steel is inserted in the hole, the tapered socket of the feed bar is slipped over the drill-steel shank, and work proceeds as before. To obtain the final cut an extension bar is used.

After the three rib holes have been drilled the column is first moved to the center and then to the opposite side of the face to drill the remaining holes. Three rib holes are always drilled, while one to three holes are drilled in the center, depending upon the height of the face and the condition of the bottom.

The top holes are collared at a point 30 inches from the roof and are drilled upward at an angle of about 35° from the horizontal. The rib holes are placed at an angle of 25° toward the rib at about 2 feet from the rib line. The middle hole is drilled at about 2° above the horizontal and 25° toward the rib. The bottom holes are drilled at approximately 10° below horizontal. The top holes are placed so that the collars are 30 inches from the roof, and they are pointed so as to terminate about 6 inches below the roof line. The bottom holes are started 8 inches above the floor and end in the floor itself. Figure 4 shows the drill-hole arrangement for a 9-hole face.

The holes are generally drilled to a depth of 7 feet. Usually 4-1/2 minutes are required to drill a hole of this depth at a speed of about 18 inches per minute. Usually a little longer time is required to drill the bottom holes, as they are in much harder material.

A drill crew consists of two men - a regular driller and a timberman - who always work together in the same face. Generally their work is such that each is kept busy with his own duties. However, when necessary one assists the other, and occasionally the timberman may even run a second drill. In addition to these duties the two men must also lay whatever track is necessary and maintain their rooms and entries. After all holes have been drilled these two men load and, at the end of the shift, fire them. On account of having to perform so many duties these men drill only one face per day. To obtain the necessary tonnage two of these drill-timberman crews are necessary.

Thus paired, these men exercise great care in placing timber sets close to the face and also in properly loading the drill holes. They are paid at the rate of 62 cents per hour. The company provides drill steel and tools. An average of 1.7 tons of clay is obtained per foot of hole drilled.

Blasting

The explosives used are 1-3/4- by 8-inch pellet powder and 60-percent L. F. gelatin dynamite size 1-1/4 by 8 inches. Double-tape safety fuse cut approximately 8 feet long is used with No. 6 caps.

Five sticks of the pellet powder are placed in each of the three top holes and also in the middle holes, while seven sticks of gelatin dynamite are placed in each of the bottom holes. The detonators are inserted in the last stick.

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Tamping shells, 2-1/2 by 12 inches, filled with drill cuttings at the face, are used to stem the holes.

An average round of nine holes produces approximately 75 tons of broken clay, which is at the rate of 0.36 pound of explosive per ton of clay mined. All blasting is done at the end of the shift after the men have departed for the surface.

Loading

Six loaders are required to load the broken clay by hand. Each man works alone and loads 16 cars in a day, which is approximately 20 tons. These men are paid at the rate of 30 cents per car and are required to furnish their own pick, shovel, and other tools.

Transportation

Three mules, each serving two loaders, are used for pit haulage. Each driver obtains two empty cars at the foot of the slope and delivers them down a slight grade to the loading face. Upon his return to the bottom with his trip, he couples the two loaded cars onto the hoist cable, and the hoistman draws them outside. The average length of one-way haul is about 2,200 feet.

The tracks are 33-inch gage. The slope has 25-pound steel rails, the main entries have 16-pound steel rails, and the room rails are made of 3-inch by 5-inch by 8-foot oak pieces. Sixteen-pound rails and No. 2 frogs are used on all room curves. After the oak rails are worn to such an extent that they are no longer suitable for tracks they are cut in two and used for ties. All trackwork is done by the drill-timberman crews.

The mine cars (fig. 5) purchased locally are constructed of solid oak and have a capacity of 21 cubic feet. An average heaping net load of 2,500 pounds is carried. There are 16 cars in daily use, and 3 are held in reserve or undergoing repair.

The mules are brought to the surface at the end of the shift and, as they work in mud and acid water all day long, are carefully washed off with warm water before being stabled for the night.

Timbering

Three-piece untreated timber sets are used to support the overlying strata and prevent subsidence of the coal seam. They are placed 4 feet apart longitudinally down the center of each room and entry and are carried to within 8 feet of the face. The posts are round and are set 8 feet apart at the bottom and 6 feet apart at the top and are capped with a 3- by 8-inch by 8-1/2-foot oak piece and securely wedged into place. A 3- by 5-inch oak spreader is usually placed between each set at the roof line and along each row of posts and spiked to the cap pieces. The timbers used are cut locally; they are 7 to 9 feet long and have a minimum diameter of 7 inches at the small end. Oak, hickory, maple, and chestnut are used. Figure 6 illustrates the method of timbering employed.

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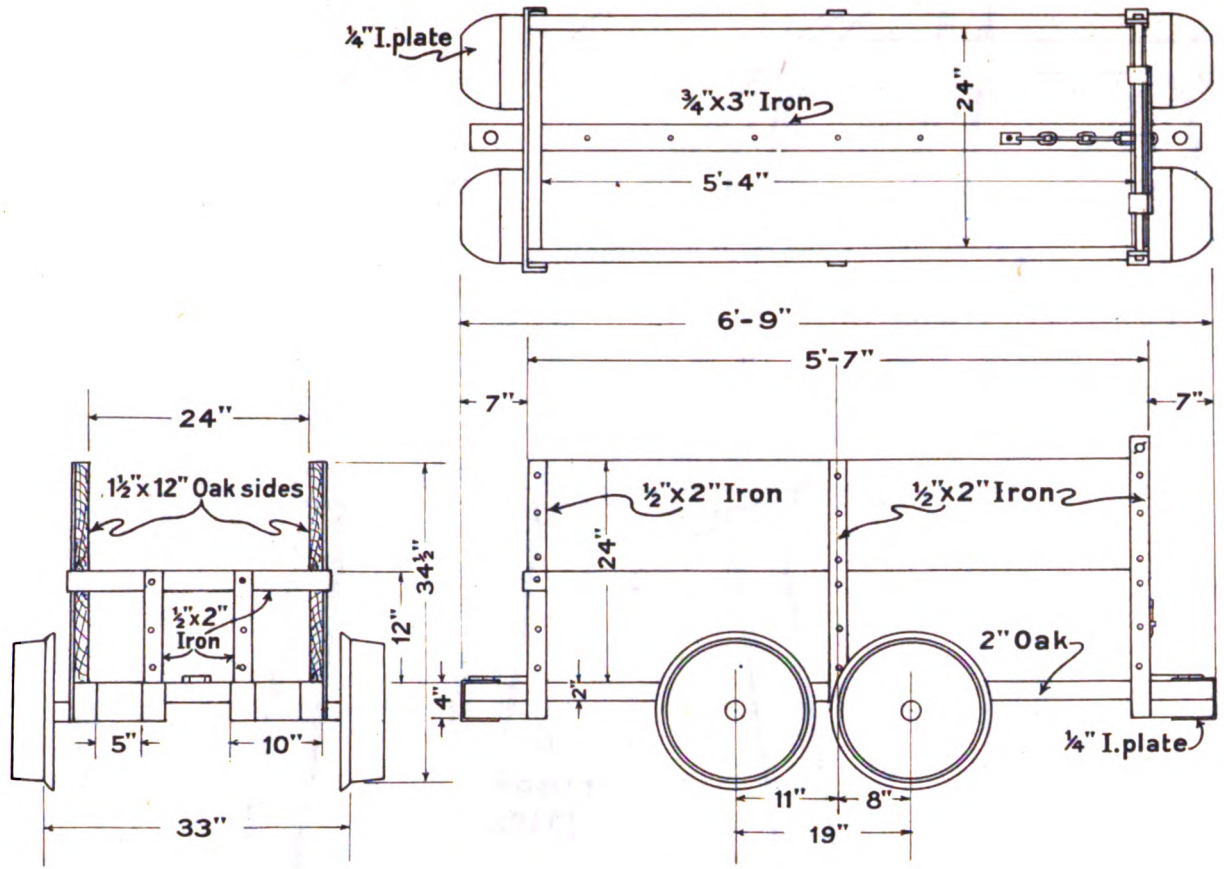

Note:

Capacity	— 21 Cu.ft.
Wheel diameter	— 15 "
Wheel face	— 3½ "
Wheel base	— 19 "
Axle	— 2 "
Gage	— 33 "

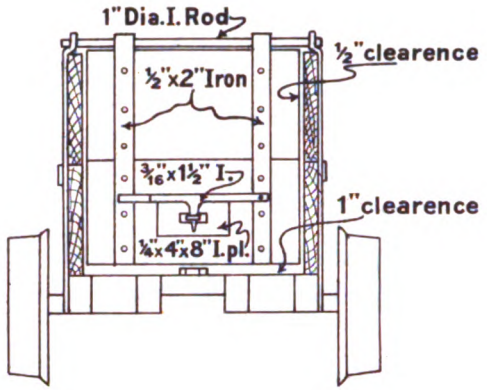

Figure 5.- Mine Car.

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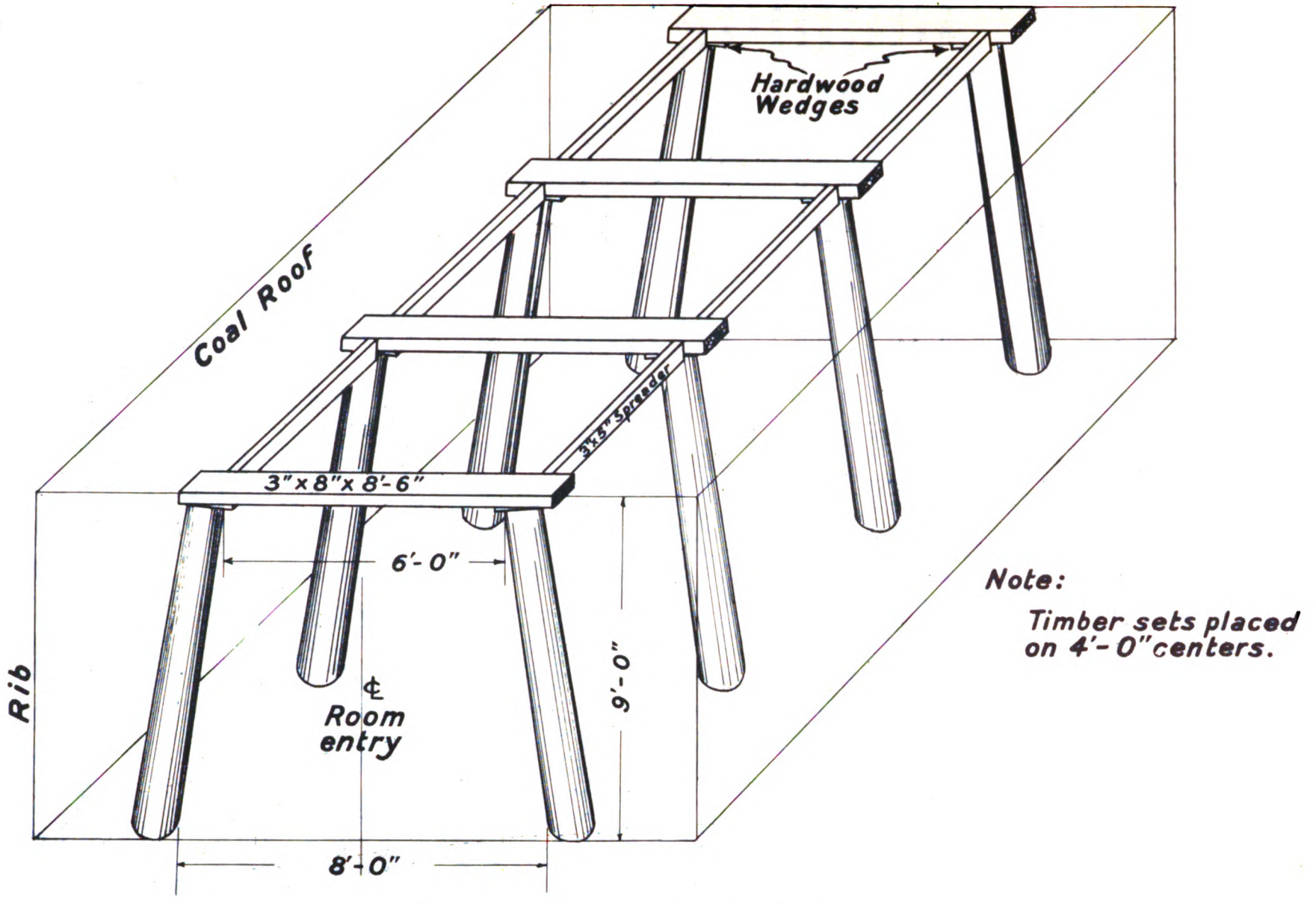

Figure 6.- Room-and-entry timbering.

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All inside timbering is done by the drill-timberman crews. Miscellaneous timbering along the main haulage entries is done by extra men when necessary. At present no extra work of this nature is being done.

The life of the timbers is 8 to 10 years. Generally, the top of the posts and the cap pieces will rot long before the bottom of the posts, even though the latter may stand in corrosive water and mud. The timber used, not including the cap pieces, averages 0.57 linear foot per ton of clay mined.

Pumping

A considerable amount of highly acid and very corrosive water is encountered, a very large part of which comes from the abandoned coal mine overhead. Three 2-inch single-stage centrifugal pumps are used as gathering pumps in the working faces. These discharge into a ditch that runs to a large sump in the northeast corner of the mine. From here the water is pumped to the surface through the air shaft by means of a 5-inch, direct-connected, single-stage, centrifugal pump. The body and impeller of this pump are made of bronze to withstand the corrosive action of the water. The pump is driven by a direct-connected, 10-horsepower, 220-volt, 24-ampere, 3-phase, 60-cycle motor at a speed of 1,800 r.p.m. On the discharge line a 5-inch wooden pipe is used. Wrought-iron pipe formerly used would last approximately 12 months. This pump is operated about 7 hours daily. Its rated capacity is 700 g.p.m. About 400 feet from the foot of the slope is a 5- by 12-inch, wooden-plunger, wood-lined pump with a rated capacity of 60 g.p.m. Considerable water from the old clay workings drains into a small sump beside this pump. A 3-inch wooden pipe line 300 feet long discharges the water into a tile line, which, in turn, conducts the water outside the mine. This pump, which operates approximately 4 hours daily, is gear-driven by a 10-horsepower, 220-volt, 3-phase, 60-cycle motor whose speed is 1,200 r.p.m. The life of the wooden plunger is about 6 months.

During the year these latter two pumps will handle an average of 1,944,000 gallons of water, which is equivalent to 113 gallons per ton of clay mined.

The three gathering pumps are described as follows: (1) A 2-inch, single-stage, direct-connected, centrifugal pump driven by a 5-horsepower, 220-volt, 3-phase, 60-cycle motor having a speed of 1,800 r.p.m. The 3-inch discharge line is 425 feet in length. Its rated capacity is 200 g.p.m. (2) A 2-inch, single-stage, centrifugal pump, belt-driven by a 3-horsepower, 220-volt, 3-phase, 60-cycle motor whose speed is 1,600 r.p.m. The 3-inch discharge line is 400 feet long. Its rated capacity is 175 g.p.m. (3) This is also a 2-inch direct centrifugal pump driven by a 5-horsepower, 220-volt, 3-phase, 60-cycle motor at a speed of 3,200 r.p.m. It discharges into the 3-inch line on the No. 2 pump listed above. Its rated capacity is 250 g.p.m.

Ventilation

In the northeast corner of the mine is a vertical air shaft that serves as a downcast. A 36-inch-diameter, 4-blade disk fan driven by a 5-horsepower, 220-volt, 3-phase, 60-cycle motor whose speed is 1,800 r.p.m. is housed in a small frame building on the surface. The rated capacity of this fan is 10,000 cubic

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feet of air per minute. Good control of the air current provides excellent ventilation throughout the mine. The air shaft is 42 inches square inside the cribbing and is 35 feet deep. It is close-cribbed throughout with 3- by 8-inch oak and was raised from the mine workings.

Hoisting

A small, single, cone-friction drum, electric hoist is used to pull a trip of two cars from the slope bottom. The drum, which is 12 inches in diameter and 17 inches long, has a speed of 60 r.p.m. The hoisting speed is 188 feet per minute. A 6 x 19, 1/2-inch diameter, regular-lay, plow-steel, hemp-center cable, 215 feet long, is used. When wound, this will make two complete layers on the drum. When the trip is at the bottom of the slope six turns remain on the drum. The life of this cable is ordinarily 12 months. A single 6-inch-diameter, double-flanged idler is located at the top of the slope. The hoist motor is 10-horsepower, 220-volt, 26-ampere, 3-phase, and 60-cycle with a speed of 1,720 r.p.m. It drives the hoist through a 6-inch by 14-1/2-foot rubber transmission belt.

The gross weight of the trip of two cars is 7,400 pounds. It requires 1 minute to hoist this load from the bottom of the slope to the surface. The average day's hoist is 96 cars.

The hoist engineer also operates the roll crusher and the first large conveyor belt that carries the crushed clay to the storage pile. The cars are pulled over the hump by the hoist, uncoupled, and then pushed over to the "kick-back" dump (fig. 7) directly above the crusher. After being dumped the empty car is pushed onto the empty car track, the two are coupled, the cable is attached, and they are pushed over the hump and allowed to start on their downward journey. The hoist engineer stands beside the slope entrance during the descent, from which place he controls the rate of speed of the cars by means of a lever and a cable that runs from this point to the brake on the hoist.

The "kick-back" dump is 36 inches long, with a 3-inch-diameter shaft placed 18 inches from the inside of the curved rail of the horn. It has a suitable counterbalance at the end of a 6-foot arm attached to the floor of the dump (fig. 7).

Pillar Drawing

At present no pillars are being drawn. The cross-hatched portion of figure 3 covers the area that has been robbed. As will be noted, the pillars have been pretty well drawn in the south section, but in the north section this work has not been begun.

Miscellaneous

In several places along the main haulage entries some squeezing is evidenced by piercing of the soft bottom by the posts and the resultant settling of the roof. Several places where lateral pressure of the pillars was great enough to cause the posts of each set to squeeze inward, thereby narrowing the areaway, also were noted. Better drainage of these areas might have prevented some of this movement.

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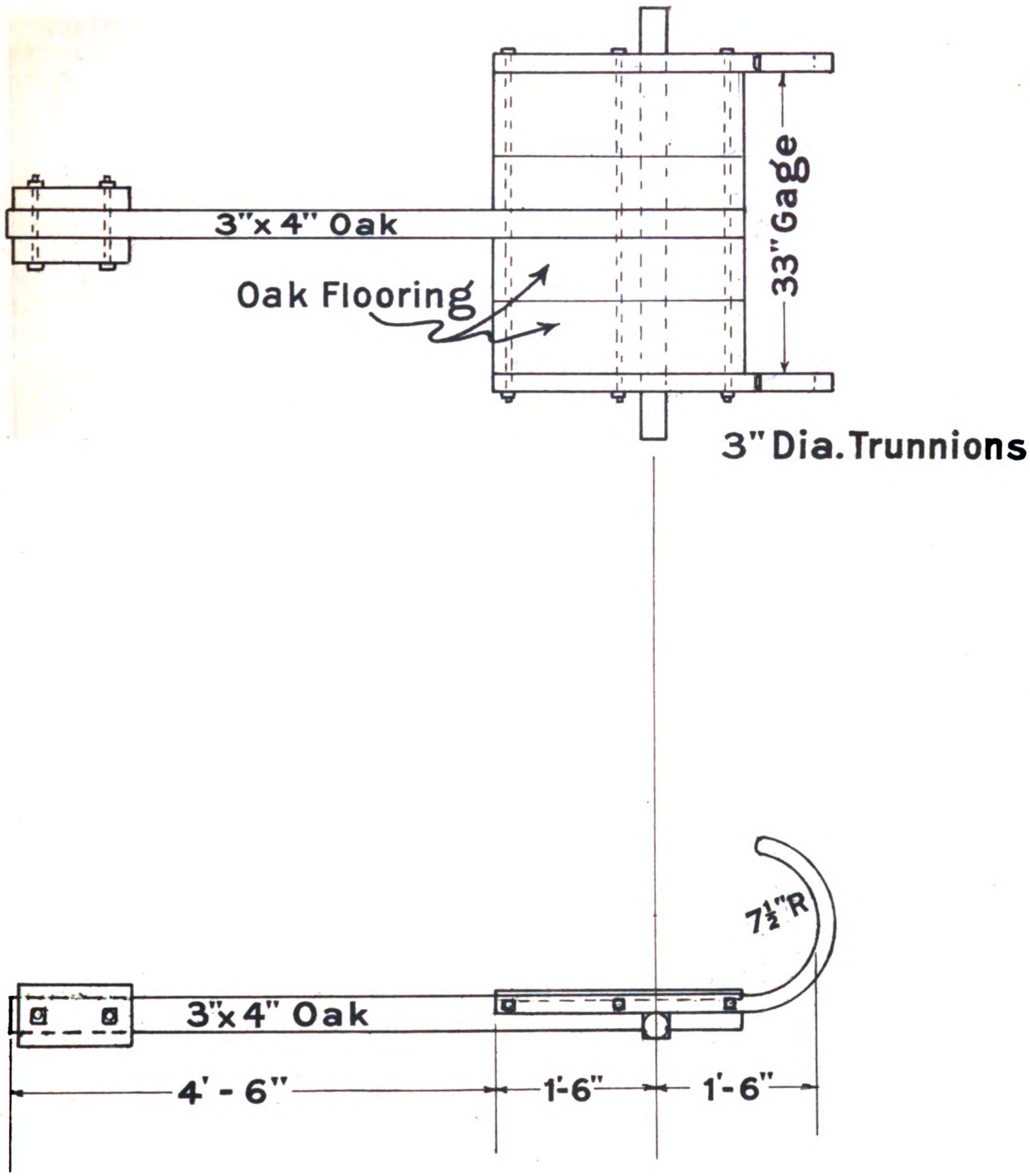

Figure 7. - Kick-back dump.

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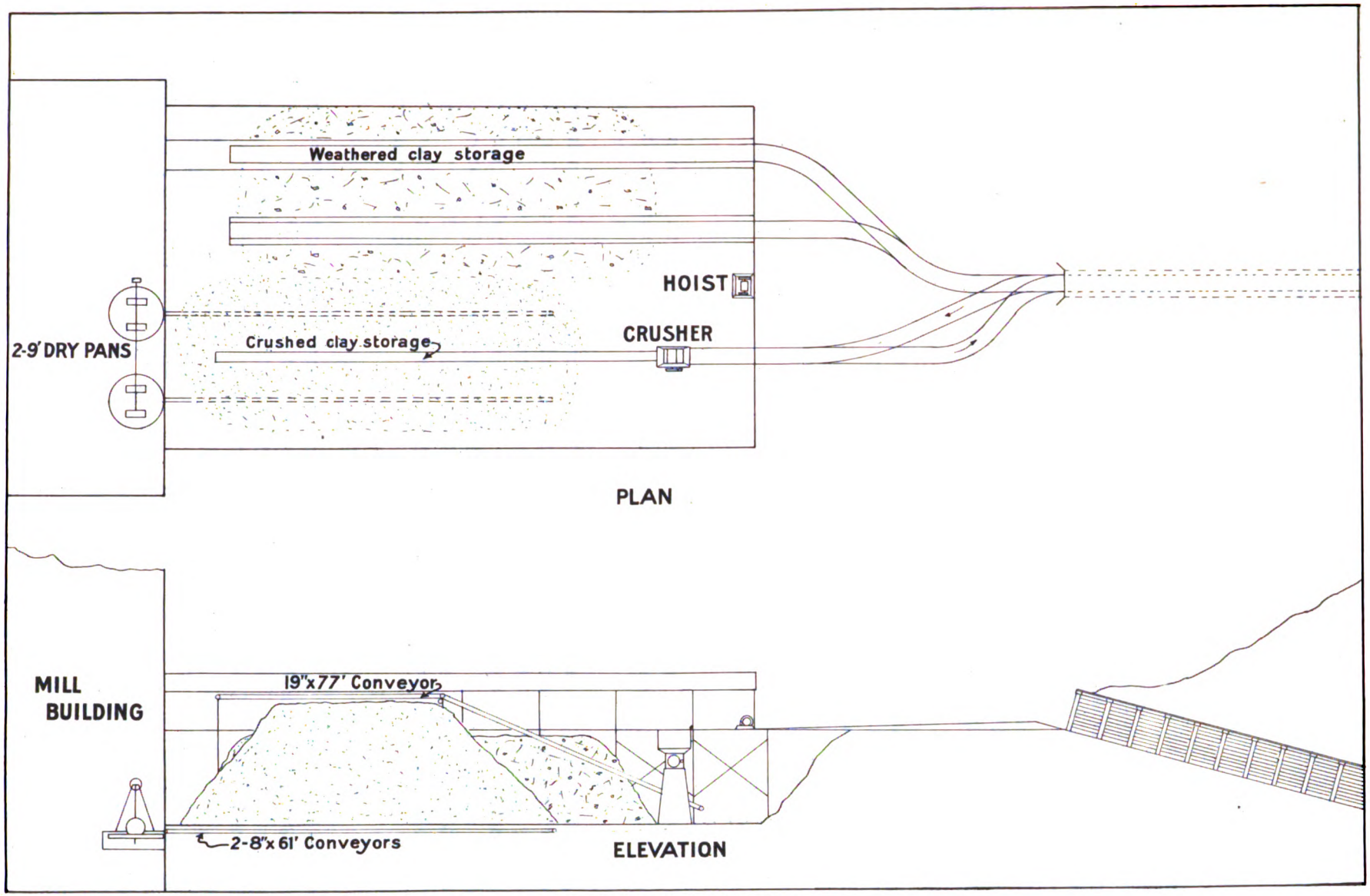

FIGURE 8.-STORAGE.

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Sloughing is quite common, and some places are now 18 to 20 feet wide. The sloughed clay is permitted to remain in place; it is planned to recover it when the pillars are drawn.

Outside Storage

In addition to the crushed-clay storage pile described below another stock pile is provided for the weathering of the mined clay before it is crushed. (Fig. 8.) This consists of a covered wooden trestle approximately 15 feet high, carrying two tracks on 12-foot centers. Removable floor boards are placed between the rails for a walkway so that the cars can be easily pushed to the desired dumping point. As will be noted from the sketch (fig. 5), the mine car is narrow enough to permit dumping it between the rails, and the center of the wheel base is 3 inches behind the center of the car. Dumping is done by the hoist engineer. The capacity of this stock pile is approximately 1,800 tons.

Clay is reclaimed from the stock pile by hand. It is shoveled into wheelbarrows and dumped through an opening in the floor over the west conveyor belt. It is then conveyed to the dry pan, where it is usually ground along with the run-of-mine clay.

MILLING METHODS

Crushing

The mine cars are dumped into a wooden hopper 40 by 60 by 62 inches having a capacity of one car of clay. This hopper is built directly over the single-roll crusher.

The crusher has an 18-inch-diameter roll, 30 inches long, mounted on a 5-1/2-inch shaft whose speed is 42 r.p.m. Three- by three-inch removable teeth stud the roll. The capacity of the crusher is such that ordinarily it is running empty long before the second car is dumped. Its operating capacity, at a peripheral speed of 197 feet per minute, is 50 tons per hour. It is driven by a 30-horsepower, 220-volt, 3-phase, 60-cycle motor whose speed is 680 r.p.m. A 10-inch by 16-foot rubber transmission belt is used. The maximum size of the product produced is 6 inches.

Stock Pile

The clay from the roll crusher falls directly onto a 19-inch by 77-foot rubber conveyor belt, whence it is taken to the stock pile. The first section of this belt, 42 feet in length, is troughed and inclined upward at an angle of 23° from the horizontal. The remaining 35-foot flat section runs horizontally. The driving pulley, which has an 18-inch diameter and a 22-inch face, operates at a speed of 64 r.p.m. The capacity of the conveyor, at a speed of 300 feet per minute, is 130 tons per hour.

A 7.5-horsepower, 220-volt, 19.4-ampere, 3-phase, 60-cycle motor, whose speed is 1,720 r.p.m., drives this conveyor through a countershaft drive. The

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first reduction from the motor has a 5-inch by 18-foot rubber transmission belt. The final reduction to the head shaft has cut spur gears. The motor is inside the main plant building just opposite the end of the conveyor.

A simple board plow is used to remove the crushed clay from the belt where it falls onto the stock pile below. The stock pile proper is under the 35-foot horizontal section of the belt. Its capacity is about 990 tons of crushed clay.

Beneath the floor of the stock pile are two conveyors, each 8 inches by 61 feet, that are used for reclaiming the stock clay. These are placed parallel to and 6-1/2 feet from each side of the first large conveyor overhead. They run on 16-inch-diameter pulleys traveling at 60 r.p.m. The capacity of each of these conveyors at a speed of 250 feet per minute is 16 tons per hour. They are driven by means of a sprocket and chain 7 feet 3 inches in length from the horizontal shaft of the dry pan, into which they discharge their load. Removable floor boards over these belts permit their receiving feed anywhere along their entire length. The dry-pan operators regulate the feeding of these belts from the floor of the stock pile. (Fig. 9.)

Grinding

Two standard 9-foot dry pans are employed for the grinding operation. These units have a forged-steel vertical shaft 8 inches in diameter at the bottom and 6 inches in diameter at the top. A heavy forged shoulder near the lower end carries the heavy pan bottom. Mullers, with a diameter of 54 inches and a face of 12 inches, provide the necessary grinding action against the pan bottom. Sectional screen plates with 3/16-inch slots are placed just outside the path of the mullers. The life of a screen plate is about 8 months. Each machine, run at a speed of 32 r.p.m., has a capacity of 10 tons per hour.

A single countershaft running across the top of the two pans drives these units through square-jawed clutches. The countershaft is driven from a main-line shaft by means of a 24-inch by 20-feet 7-inch transmission belt at a speed of 92 r.p.m.

Elevating

The ground clay from each dry pan falls into the well of a separate enclosed belt-and-bucket elevator, which lifts it to the top of the building and discharges it over the screens. These elevators are identical in size, speed, and capacity. They are 16 inches by 42 feet and are placed at an angle of 3° from the vertical. The buckets measure 6 by 14 inches and are spaced 14 inches. The pulleys, which are 30 inches in diameter, have a speed of 32 r.p.m. Their individual capacities at a speed of 250 feet per minute are 116 tons per hour. Both elevator drive pulleys are mounted on the same horizontal shaft that is driven through a 12-inch by 22-1/2-foot rubber transmission belt from a countershaft on the second floor of the building. This countershaft, in turn, is driven from the main-line driveshaft on the ground floor.

Screening

The discharge of the east or No. 2 elevator can be run over either of two 3- by 16-foot stationary screens, inclined at an angle of 35° from horizontal.

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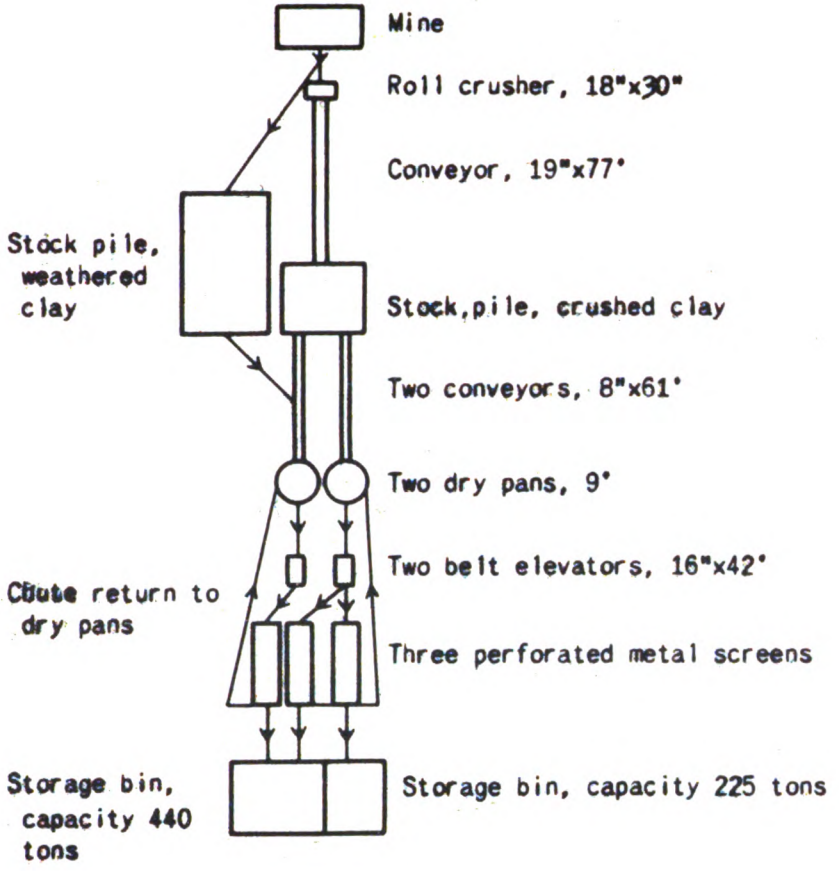

Figure 9.- Flow sheet.

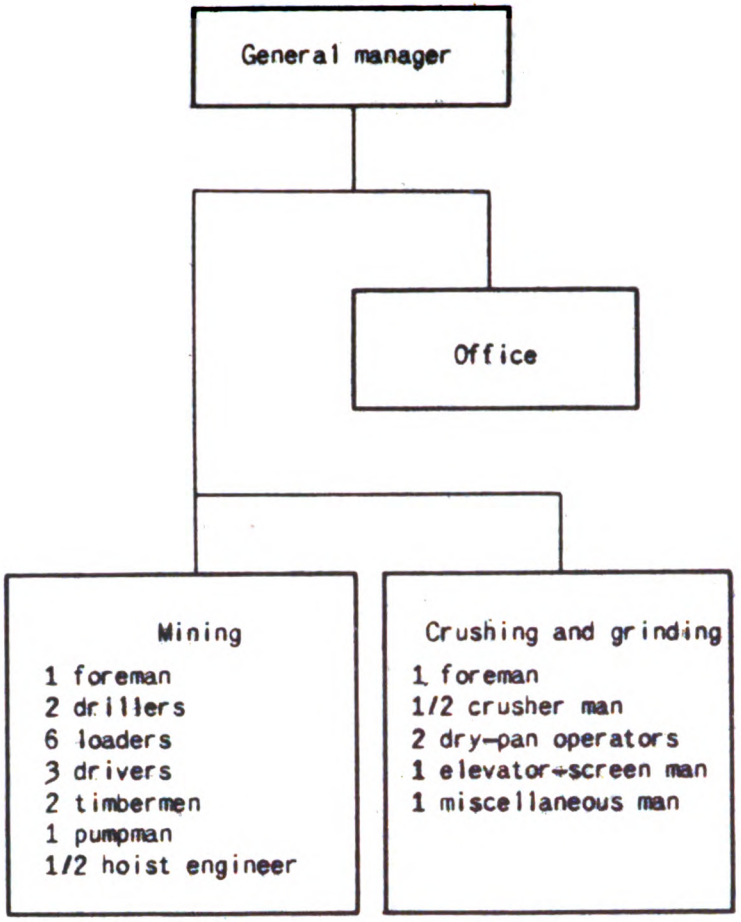

Figure 10.- Organization chart.

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Screen plates, 3 by 4 feet and 1/16 inch in thickness, (fig. 9) having round perforations, are assembled end to end to make up the screening surface. Plates with the same or different perforations are used, depending upon the product manufactured. The perforations are from 3/32 to 3/16 inch in diameter. The number of plates and the diameter of perforations used at present on these two screens are as follows: No. 3 screen has four plates with 3/32-inch perforations. In No. 2 screen the first plate has 3/32-inch perforations and the remaining three plates have 5/32-inch perforations. These two screens are designated as screens no. 3 and no. 2 in the following chapter on "Screen Analysis."

All the material passing through no. 3 screen falls into a chute and drops into no. 2 finished storage bin. The material that passes over this screen falls into a 12- by 12-inch wooden chute and is returned to the dry pan below. The material that passes through no. 2 screen falls into a chute and drops into no. 1 finished bin. Oversized material is returned to the dry pan through a 12-inch by 12-inch wooden chute.

The finely ground clay from the west or no. 1 elevator is discharged over a single stationary screen of the same size and inclination as described above. This screen (no. 1) is similar to screen no. 2. The undersized clay falls into no. 1 finished storage bin. The oversized material falls into a second 12- by 12-inch wooden chute, whence it is returned to the dry pan. This screen is designated as screen no. 1 in the following section on "Screen Analysis." Different-size perforations are used in nos. 1 and 2 screens so as to obtain the proper proportion of the various sizes of the clay particles for the particular product manufactured.

Storage Bins

No. 1 bin is made up of 1- by 3-inch lumber placed on end backed by 2 by 10's. It is 17-1/2 feet long by 14-1/2 feet wide and 21-1/2 feet high. Its capacity is 440 tons of finished clay.

No. 2 bin is also made of 1- by 3-inch lumber, as above, but its size is 9 by 14-1/2 feet by 21-1/2 feet. Its capacity is 225 tons.

Simple vertical wooden spouts in the bottom of the bins permit the flow of ground clay into the two wet pans beneath. An additional spout is provided in no. 2 bin so that this clay can be drawn off for shipment as fine ground clay. However, the hand-molded department uses the bulk of this fine clay.

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Screen Analysis and Weight Per Cubic Foot

Samples taken by the writer while the screens were assembled, as described above, gave the following results (determinations by the U. S. Bureau of Mines laboratory at Pittsburgh, Pa.):

SCREEN ANALYSIS

Sample from -	Screen size (mesh)	Retained on -									Passing 200
		14	20	28	35	48	65	100	150	200	
Screens 1 and 2 ..	Percent	3.1	10.7	12.9	13.5	12.5	8.9	8.7	5.2	6.0	18.5
	Cumulative .	3.1	13.8	26.7	40.2	52.7	61.6	70.3	75.5	81.5	100.0
Screen 3	Percent	4.5	15.4	12.3	8.6	8.1	5.8	6.6	4.8	5.8	28.1
	Cumulative .	4.5	19.9	32.2	40.8	48.9	54.7	61.3	66.1	71.9	100.0

SPECIFIC GRAVITY - WEIGHT PER CUBIC FOOT

Sample from -	Specific gravity	Weight, pounds per cubic foot
Screens 1 and 2 ...	2.650	165.6
Screen 3	2.653	165.8

Miscellaneous Plant

Three 150-horsepower, horizontal, fire-tube boilers are in daily use. They supply steam for the large engine described below, for two pipe presses, for the drying rooms, and for heating the various buildings. No. 6 coal from the company's own mine nearby is used.

Motive power for the main-line shaft in the plant is supplied by a 150-horsepower, 16- by 36-inch Corliss valve engine. This line shaft, 4-15/16 inches in diameter, is coupled direct to the flywheel shaft and travels at a speed of 92 r.p.m. The latter, in turn, drives a countershaft on the second floor of the shop building. These two shafts drive the two dry pans and their feeding conveyors, two dry-pan elevators, two wet pans, the wet-pan elevator, and the press-feeder conveyors. Figure 9 is the flow sheet of the operation just described.

Power

Electric power is purchased from the Chio Power Co. on a sliding-scale basis. The rate at present averages $0.035 per kw.-hr.

PERCENT EXTRACTION

In the first mining operation a recovery of about 20 percent is obtained. This applies only to the thickness of clay mined and not to the entire thickness of the Lower Kittanning member.

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In those areas where pillars have been drawn, a final recovery of about 90 percent has been obtained, the remaining 10 percent being lost through contamination from roof falls, sloughing, and squeezes.

In the worked-out areas where pillars have not been drawn it is doubtful if this clay will ever be recovered, because the additional cost of re-entering these working places and putting them in workable condition would be prohibitive. The cost of retimbering, relaying pipe lines, track, etc., would more than offset the value of the clay involved.

EMPLOYEE PAY SYSTEM

Compensation is paid on an hourly basis, with the exception of that of the 6 loaders, who are paid 30 cents per car. The following rates for an 8-hour day are in effect:

Labor classification	Number of men	Hourly rate	Hours per day
Drillers	2	$0.62	8
Drivers	3	.62	8
Timbermen	2	.62	8
Pumpmen	1	.59	8
Hoist and crusher men	1	.59	8
Dry-pan operators	2	.47	8
Screen and elevator operators	1	.47	8
Repairman	1	.55	2
Miscellaneous	1	.47	8
Mine foreman	1	Salary	-
Plant foreman	1	Salary	-

SAFETY METHODS AND FIRST-AID ORGANIZATION AND TRAINING

All employees are urged to practice safety in their daily work. First-aid materials are provided for miner injuries. Stretchers are available for use in case of serious accident, and a doctor's office is only a few miles distant. No first-aid organization is maintained nor is a training class conducted at present.

FORM OF ADMINISTRATIVE ORGANIZATION

Figure 10 is an organization chart. Each foreman has complete jurisdiction over his own department, selects his own personnel, and reports directly to the general manager.

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I. - SUMMARY OF COSTS

NAME: Dennison Sewer Pipe Co., Dennison, Ohio. PERIOD COVERED: 1935

TOTAL TONS CLAY LOADED: 17,160.

Operating Costs Per Ton Clay Mined

Classification	Labor	Supervision	Air drills, steel	Power cost	Fuel cost 1/	Explosives	Other supplies	Total
Drilling and blasting ..	$0.0830	.....	$0.0011	.....	.....	$0.0401	$0.0006	$0.1248
Loading	.2435	.....	.....	.....	.....	.....	.0017	.2452
Transportation	.1541	.....	.....	.....	.....	.....	.0556	.2097
Timbering ...	.0767	.....	.....	.....	.....	.....	.0432	.1199
Pumping	.0653	.....	.....	$0.0852	.....	.....	.0121	.1626
Hoisting	.0196	.....	.....	.0022	.....	.....	.0049	.0267
Miscellaneous	.....	$0.0980	.....	.0047	.....	.....	.0207	.1234
Crushing	.0141	.....	.....	.0176	.....	.....	.0020	.0337
Grinding	.0533	.....	.....	.....	$0.1706	.....	.0189	.2428
Screening ...	.0156	.....	.....	.....	.....	.....	.0033	.0189
Elevating ...	.0156	.....	.....	.....	.0209	.....	.0007	.0372
Conveying ...	.0225	.....	.....	.0026	.0014	.....	.0007	.0272
Storage, in .	.0226	.....	.....	.....	.....	.....	.0006	.0232
Storage, out	.....	.....	.....	.....	.....	.....	.....	.....
Miscellaneous	.....	.0102	.....	.....	.....	.....	.0012	.0114
Total	.7859	.1082	.0011	.1123	.1929	.0401	.1662	1.4067

1/ Estimated.

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II. - SUMMARY OF COSTS IN UNITS OF LABOR, POWER, AND SUPPLIES

NAME: Dennison Sewer Pipe Co., Dennison, Ohio **PERIOD COVERED:** 1935.

TOTAL TONS MINED: 17,160.

	Mining	Crushing	Other	Total
Labor (man-hours per ton):				
Drilling and blasting	0.12			0.12
Loading	.40			.40
Haulage	.21			.21
Timbering	.12			.12
Pumping	.07			.07
Hoisting	.03			.03
Miscellaneous	.06	0.03	0.23	.32
Total labor	1.01	.03	.23	1.27
Average tons per man per shift	7.74	120.	34.3	6.3
Labor, percent of total cost	....	.....	.....	63.41
Power and supplies:				
Explosives (lb. per ton)	.36	.....	.....	.36
Timber (lin. ft. per ton)	.57	.....	.....	.57
Total power:				
Drilling	.....	.....	.....	.....
Locomotive	.....	.....	.....	.....
Pumping, kw.-hr.	2.43	.....	.....	2.43
Hoisting, kw.-hr.	.06	.....	.....	.06
Ventilation, kw.-hr.	.19	.....	.....	.19
Crushing, kw.-hr.	.....	.50	.....	.50
Grinding, hp.-hr.	.....	.....	6.89	6.89
Screening	.....	.....	.....	.....
Elevating, hp.-hr.	.....	.....	.70	.70
Conveying, hp.-hr.	.....	.07	.12	.19
Other supplies, in percent of total supplies	.....	.....	.....	51.01
Supplies and power, percent of total cost	.....	.....	.....	36.59

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III. - DETAILED SUMMARY COSTS - DIRECT OPERATION MINE

NAME: Dennison Sewer Pipe Co., Dennison, Ohio. PERIOD COVERED: 1935.

TOTAL TONS LOADED: 17,160.

Classification	Amount	Cost per ton	Total cost per ton
Loading	$4,204.40	$0.2452	$0.2452
Drilling:			
Operating labor	1,194.58	.0696	
Air, gas, power			
Operating supplies	19.75	.0011	
Repair labor	52.00	.0030	
Repair supplies	10.00	.0006	
Total drilling	1,276.33	.0743	.0743
Blasting:			
Labor	177.32	.0104	
Explosives	688.50	.0401	
Other supplies			
Total blasting	865.82	.0505	.0505
Haulage:			
Locomotive			
Mules	2,835.15	.1652	
Cars	214.00	.0124	
Track maintenance	552.32	.0321	
Total haulage	3,601.47	.2097	.2097
Timbering:			
Labor	1,319.90	.0767	
Supplies	741.00	.0432	
Total timbering	2,060.90	.1199	.1199
General charges	5,365.65	.3127	.3127
Grand total	17,374.57	1.0123	1.0123

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